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AUTHOR Jonassen, David H.; And Others
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ABSTRACT

Diagrams showing the components of structural knowledge and the theoretical basis for structural knowledge introduce four tables presenting information on: (1) implicit strategies for conveying cognitive structure, including content/structures signalling (Meyer), frames/slots (Armbruster and Anderson), and Elaboration Theory (Reigeluth and Merrill); (2) explicit strategies for conveying structural knowledge, including advance organizers (Ausubel), graphic organizers (Barron), pictorial graphic organizers (Hawk, McLeod, and Jonassen), structured notetaking (Smith and Tompkins), concept maps (Novak and Gowin), and cognitive maps (Diekhoff and Diekhoff); (3) structural knowledge learning strategies (structural maps, pattern notes, semantic analysis of pattern notes, concept maps, networking, analysis of key ideas, and NAIT--the Node Acquisition and Integration Technique); and (4) strategies for assessing knowledge structures (reading time tests, semantic recall tests, hierarchical timing tests, pattern notes, free word association tests, controlled word association tests, tree construction tasks, concept maps, membership decision tasks, generating examples, conceptual models, concept typicality ratings, subtraction technique, actual tasks, think-aloud tasks, diagnostic tests, scanning time, mazes, human mazes, field and ground tests, and mental rotation tasks. Information provided in each of the tables includes the strategy, a description, procedures, uses, advantages, and disadvantages. (BBM)

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Title:

Conveying, Assessing, and Learning (Strategies for) Structural Knowledge

Authors:

David H. Jonassen
Kathy Beissner
Rick Kenny
Karen Jost
David Reid
Michael Yacci

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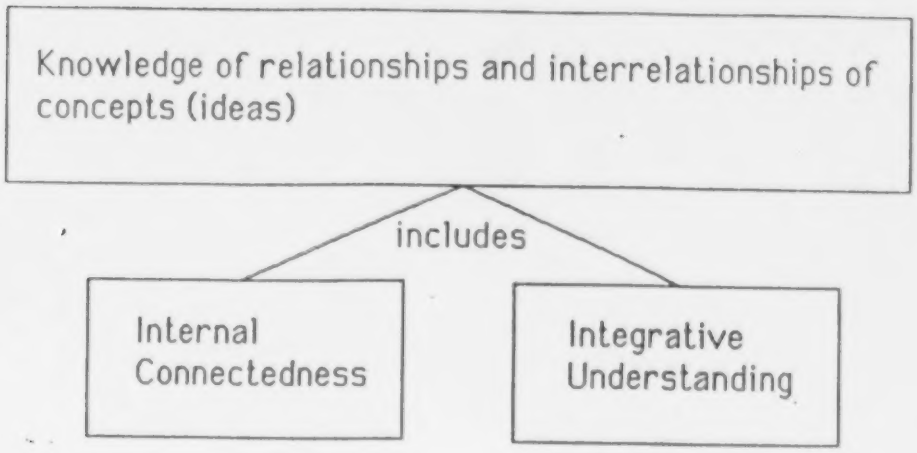
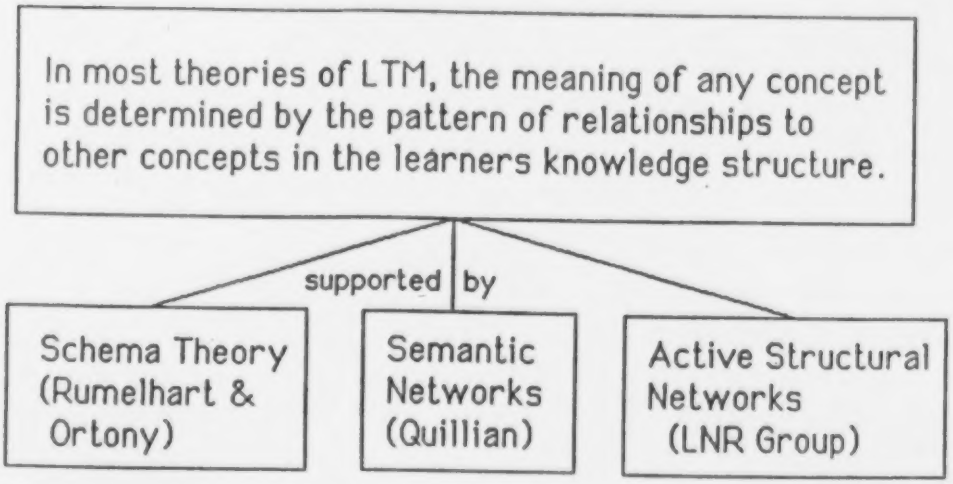
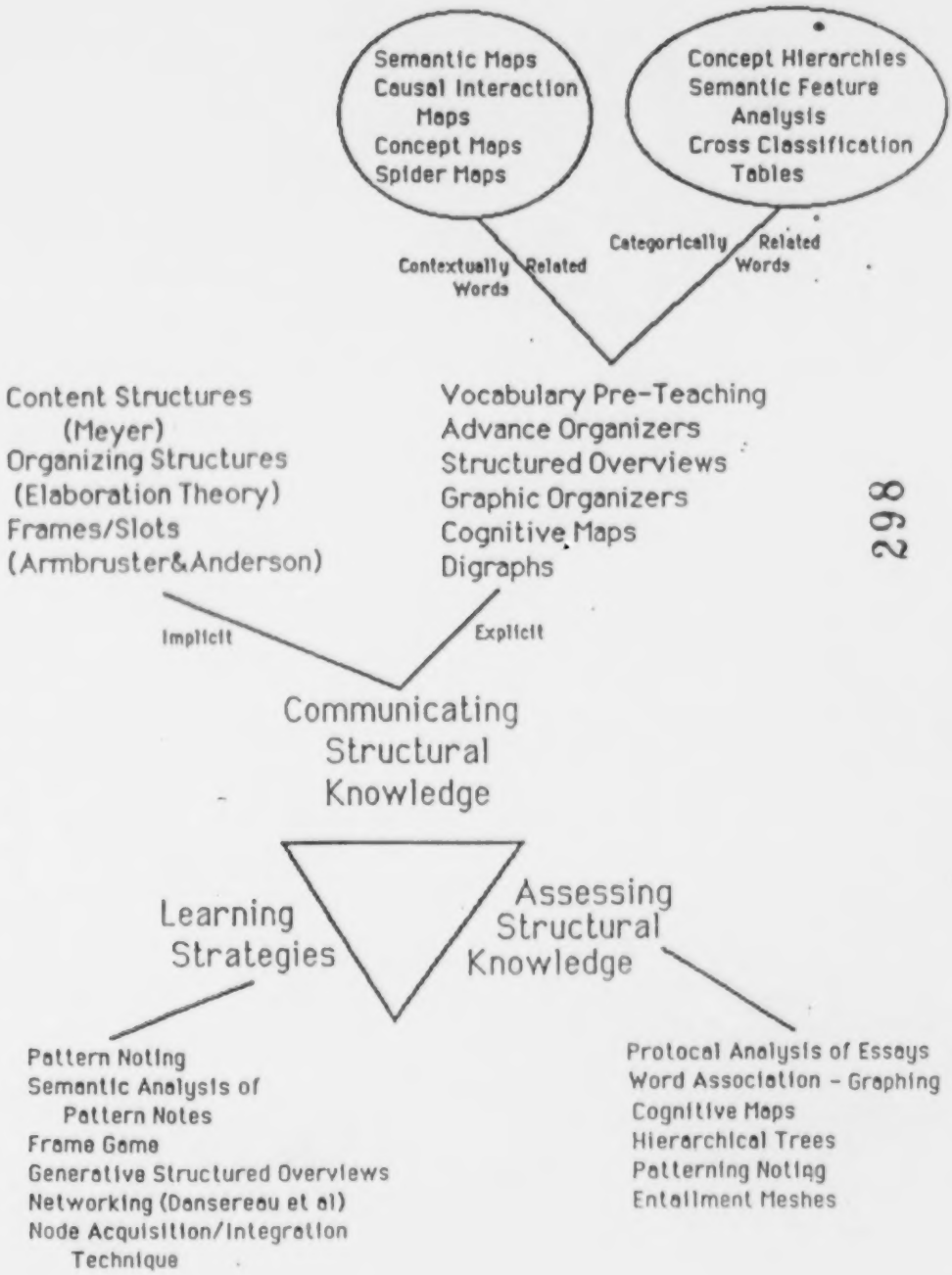
Structural Knowledge



Theoretical Basis for Structural Knowledge


In most theories of LTM, the meaning of any concept is determined by the pattern of relationships to other concepts in the learners knowledge structure.
supported by
Schema Theory (Rumelhart & Ortony)
Semantic Networks (Quillian)
Active Structural Networks (LNR Group)


Semantic Maps
Causal Interaction Maps
Concept Maps
Spider Maps
Concept Hierarchies
Semantic Feature Analysis
Cross Classification Tables
Contextually Related Words
Categorically Related Words
Content Structures (Meyer)
Organizing Structures (Elaboration Theory)
Frames/Slots (Armbruster&Anderson)
Vocabulary Pre-Teaching
Advance Organizers
Structured Overviews
Graphic Organizers
Cognitive Maps
Digraphs
Implicit
Explicit
Communicating Structural Knowledge
Learning Strategies
Assessing Structural Knowledge
Pattern Noting
Semantic Analysis of Pattern Notes
Frame Game
Generative Structured Overviews
Networking (Dansereau et al)
Node Acquisition/Integration Technique
Protocal Analysis of Essays
Word Association - Graphing
Cognitive Maps
Hierarchical Trees
Patterning Notiag
Entailment Meshes

Implicit Strategies for Conveying Cognitive Structure

STRATEGY	DESCRIPTION	APPLICATIONS	ADVANTAGES	DISADVANTAGES
Content/Structures Signalling B. Meyer	Five basic organizing schemes convey the structure of prose to learners: Collection Description Causation Problem/Solution Comparison These organizing schemes are used to identify the top-level organizing strategy for the text that follows. The remainder of the content is then depicted in a hierarchical chart, which serves to guide the writing. Signals are more explicit means of conveying the relationships between concepts. Signals are non-content words that point out the structure, or highlight key ideas.	Design of text or other discourse Basis for a learning strategy: learners can be taught to recognize and use author's organizing structures. Using the author's organizing structure facilitate recall.	Research has validated the value of using organizational schemes to structure text, especially for lower ability learners. Studies have shown that learners who can recognize and use the author's organizing scheme have better retention and recall of information. Use of content structures can assist writers in conveying their message to readers.	Due to the nature of the medium (written or spoken discourse), hierarchical relationships are emphasized Interrelationships between concepts are not addressed. Researched only on text or spoken prose. May have some implications for design of other types of instruction.
Frames/Slots B. Armbruster and T. H. Anderson	Frames are content dependent structures used to organize text. There are two types of frames: Static frames organize content by the attributes of key concepts. Dynamic frames organize content by showing relationships between principles. Slots are categories of information within the generic frames, which are filled in with the important information.	Design of text Adjunct exercises Testing methods	Static frames are fairly easy to identify and construct. Use of frames/slots provides consistant structure from chapter to chapter, or topic to topic, thus reinforcing key components of the content area. Frames and slots can help to organize a writer's thoughts, and ensure that the important content is included in the Instruction (e.g., the writer does not "forget" to include Instruction on a key attribute of a concept).	A limited number of generic frames have been identified. There is limited research on the effectiveness and efficiency of using frames to structure instruction. Prescriptions for constructing dynamic frames are tinted. This organizing scheme also addresses primarily a hierarchical structure. Interrelationships between concepts must be embedded within the general framework.

Implicit Strategies for Conveying Congitive Structure

STRATEGY	DESCRIPTION	APPLICATIONS	ADVANTAGES	DISADVANTAGES
Elaboration Theory Reigeluth, Merrill	The sequence of instruction and it's organizing content implicity convey the structure of the subject matter. Three types of content are used to organize instruction: Conceptual, Procedural, or Theoretical. Top level structure is demonstrated by selecting one of these three content types as the basic organizing content for instruction. Instruction begins by presenting a simple but realistic application of the content to be learned, gradually elaborating on the initial instruction to more complex applications. Explicit components of the elaboration theory include use of synthesizers to show interrelationships between content. The epitome lesson explicitly conveys the structure of the content by providing a special type of overview.	Textbooks Individualized Instruction Courses	The elaboration theory prescribes a simple to complex sequence which is hypothesized to build stable cognitive structures and provide for meaningful "application level" learning at the outset of Instruction.	Limited empirical verification of the effectiveness and efficiency of elaboration sequence Elaboration sequences are relatively difficult to construct.

Explicit Strategies for Conveying Structural Knowledge

STRATEGY	DESCRIPTION	APPLICATIONS	ADVANTAGES	DISADVANTAGES
Advance Organizers D. Ausubel	Purpose: to facilitate the learning and retention of meaningful verbal information. Based on Ausubel's Subsumption Theory of meaningful verbal learning which suggested that cognitive structure is hierarchically organized in terms of highly inclusive concepts under which are subsumed less inclusive concepts and informational data. Presented <u>in advance</u> od the material-to-be-learned and at a higher level of abstraction, generality and inclusiveness. <u>Expository Form:</u> provides relevant proximate subsumers. Used when material is unfamiliar and no concepts are known to which new ones can be anchored. <u>Comparative Form:</u> integrates new concepts with basically similar concepts in cognitive structure. Used when learners are familiar with material to which new concepts can be anchored. Must clearly delineate similarities between those and material-to-be-learned.	Adjunct instructional aid designed for use in expository (didactic) instruction. Best used with material which is poorly organized, difficult or unfamiliar to the reader in order to increase the discriminability of that material. Best used when the learner's ability is limited as the advance organizer facilitates the construction of an ideational framework for understanding - a weakness for low ability learners (It should be noted that the research evidence for this is equivocal). Most effective in the facilitation of long term retention.	Theory-based. Provides a meaningful context to the learner and encourages the use of that context. Can take several forms including textual verbal passages, diagrams, illustrations, concrete models, analogies, examples, sets of higher order rules, oral and visual presentations. Effective with a variety of age groups and for a wide range of subject matter.	No strong evidence for the effectiveness of advance organizers despite considerable research. Many of the most striking results conflict with the assumptions of Subsumption Theory. Advance organizers are difficult to construct. It is seldom clear what entails material at a "higher level of abstractness, inclusiveness or generality" nor is it simple to determine if the organizer will be sufficient to provide the learner with the appropriate "ideational scaffolding".

Explicit Strategies for Conveying Structural Knowledge

STRATEGY	DESCRIPTION	APPLICATIONS	ADVANTAGES	DISADVANTAGES
Graphic Organizer: Structured Overview R. Barron	Introduced as a modification of the advance organizer to improve reading instruction. Presented in the form of a tree diagram to introduce new vocabulary to be used in the material-to-be-learned. Uses the spatial characteristics of diagrams to indicate the relationships and distances between key terms.	Vocabulary instruction. Adjunct instructional aid to improve the comprehension of textual material. Can be used pre- or post-reading. Research indicates that the latter is more effective and that structured overviews do affect learning.	Can be used to activate prior knowledge. Students can construct their own structured overviews thus allowing the technique to be generative in nature.	No real basis in theory. Structured overviews are not true advance organizers as originally claimed since they are presented at the same level as the material-to-be-learned. Only presents vocabulary to be used in the passage. No description of the relationship between concepts, principles, etc., to be encountered.
Pictorial Graphic Organizer P. Hawk, M. McLeod and D. Jonassen	An extension of structured overviews. More pictorial or visual in nature. Focus is on key concepts rather than key terms. Uses the spatial characteristics of diagrams to indicate the relationships and distances between key terms. <u>Participatory form:</u> space is left for the learner to fill in key terms and details. <u>Final form:</u> the information is filled in for the learner.	Adjunct instructional aid to provide additional structure to the material-to-be-learned. Can provide a graphic synopsis of the structural interrelationships between ideas in the material-to-be-learned. Can provide a post organizer to summarize what has been learned. Can be used as a diagnostic tool to assess student learning.	Some basis in theory; i.e. Ausubel's Subsumption Theory of meaningful verbal learning via the process of integrative reconciliation. Provides the learner with advance notice of the structure of the material-to-be-learned. Provides a moderately generative learning activity. An overall structure is provided but the learner must define terms and choose what to fill in.	Not yet strongly validated in terms of research evidence. Require some training to learn to construct. Time-consuming to produce. Also, the format is not entirely clear and is subject to wide interpretation. No specific guidelines about the logical structure of the organizer although several are suggested; e.g. chronological order, simple-to-complex sequence, cause/effect.

Explicit Strategies for Conveying Structural Knowledge

STRATEGY	DESCRIPTION	APPLICATIONS	ADVANTAGES	DISADVANTAGES
Structured Note-taking P. Smith and G. Tompains	Graphic organizer in which the top level structure used by the author or inferred by the reader is explicit in the graphic. Not as pictorial in format as the pictorial graphic organizer explained above. Provides seven organizers for common text structures: - description - time/order - cause/effect - problem/solution - problem/solution/result - comparison/contrast - definition/examples	Adjunct instructional aid to provide additional structure to the material-to-be-learned. Can provide a graphic synopsis of the structural interrelationships between ideas in the material-to-be-learned. Can provide a post organizer to summarize what has been learned. Can be used as a diagnostic tool to assess student learning.	Some basis in theory; i.e. Ausubel's Subsumption Theory of meaningful verbal learning via the process of integrative reconciliation. Can provide the learner with advance notice of the structure of the material-to-be-learned if presented with an instructor generated version. If learner constructed, is an activity which is strongly generative in nature as the learner must apply the different structures to the material.	Appears to be no research evidence to validate this relatively recent technique. Requires training to be used effectively.

Explicit Strategies for Conveying Structural Knowledge

STRATEGY	DESCRIPTION	APPLICATIONS	ADVANTAGES	DISADVANTAGES
Concept Maps J. Novak and B. Gowin	Schematic devices for representing the relationships between concepts centered around key topics. Represent meaningful relationships in the form of propositions (2 or more concept labels linked by words in a semantic unit). Include concept labels and propositional statements along the links. Are hierarchical in format as they adhere to Ausubel's Subsumption Theory in which higher order (broader/more inclusive) concepts subsume new concepts or concept meanings with more specific/less inclusive underneath. Use arrows to indicate links which are not superordinate/subordinate.	As graphic organizers to allow the learner to focus on key ideas in a learning task. As post organizers to provide a schematic summary of what was learned. As a creative activity to foster recognition of new concepts. A study technique for students to review material learned or extract meaning from text. An outlining technique for preparing a paper or presentation.	If learner constructed, is an activity which is strongly generative in nature as the learner must construct meaning from the material. Provides graphic representation which can be discussed and/or altered. Novak and Gowin see it as a tool for negotiating meanings. Subtleties of meanings are provided by linking words can be revealing of student's cognitive organization. Scoring system provided which presents a method of assessing the significance of the map constructed.	Hierarchical nature may be limiting and force unnecessary structure. Requires training to use effectively; for instance, learning the difference between concept labels and linking words, choosing appropriate linking words, learning to effectively cluster the concepts, etc. Are time-consuming to construct as the development of symmetry in the map and proper clustering of the concepts may require considerable redrawing of the map. Linking words must be carefully chosen as the meanings presented can vary considerably with the term selected; e.g. the links between the concepts of "water" and "ice" could labelled in many ways including "can be", "becomes" and "sometimes is". Scoring system requires subjective judgments of meaningfulness and validity of concept relationships and cross links.

Explicit Strategies for Conveying Structural Knowledge

STRATEGY	DESCRIPTION	APPLICATIONS	ADVANTAGES	DISADVANTAGES
Cognitive Maps G. Diekhoff and K. Diekhoff	Instructor selects key concepts, terms, important events or ideas from the knowledge domain. These are arranged into pairs in matrix form. The pairs are assigned a rating from 1 (no relationship) to 9 (very strong relationship) which is converted to decimal form. A principle components analysis is performed which translates the relationship judgments to distances (highly related ideas close together and less related ones more distant). The distances are used to create the "cognitive map" - a graphic array of concept points in space.	As graphic organizers to allow the learner to focus on key ideas in a learning task. As post organizers to provide a schematic summary of what was learned.	Provide a review of prior knowledge for students. Assignment of "strength of relationship" ratings allows statistical analysis of the maps. This has led to validation of the technique indicating: 1) enhanced student essay scores. 2) increased reliability of student generated judgments. 3) increased similarity between student relationship judgments and those of the instructor.	Provide a relatively passive interaction. Not highly generative in nature. Technique requires a fairly sophisticated statistical manipulation. Cognitive maps are fairly difficult to generate and, hence, not useful as a study technique or as a technique for preparing papers, presentations, etc. Judgment of the strength of relationship between the concepts, terms, etc., is arbitrary. No guidelines provided concerning how to judge. No indication of the nature of the relationship.

Structural Knowledge
LEARNING STRATEGIES

Strategy	Description	Procedure	Uses	Advantages	Disadvantages
STRUCTURAL MAPS	Graphically represent relationships between concepts or ideas.		•note-taking •organize/reorganize information •identify important concepts (ideas) and relationships		
Pattern Notes	Organizes information in a relational manner showing linkages between topics.	•begin with central idea blocked in center of blank page, •free-associate about the subject adding lines containing related ideas, •keep elaborating on these secondary ideas.	•study technique (relationships/ self-assessment) •outlining technique (note-taking and response structuring)	•easily learned by a variety of learners •allows for multiple relationships •less constraining more individual (unique)	do not depict the nature of the relationship (except inferred)
Semantic Analysis of Pattern Notes	Post-hoc classification of the links (semantic relationships) between ideas on a pattern note.	application of an algorithm (series of questions) resulting in the classification of the semantic relationship between ideas	to identify the types of relationships between the concepts (ideas) in a pattern note	allows exploration of the nature of the relationships between ideas in a pattern note	not easily used by young learners

Structural Knowledge Learning Strategies

Strategy	Description	Procedure	Uses	Advantages	Disadvantages
Concept Maps	Graphically displays relationships between concepts in a hierarchical fashion.	•extract concepts from material •identify relationships •map top down	•self-assessment •analytical tool for extracting meaning from text, notes, also for understanding literary worth •facilitates paraphrasing •notetaking •response-structuring	•depicts relationships between concepts •promotes meaningful understanding	more constraining than pattern notes
Networking	A spatial organization of material into node-link maps or networks.	•identify important concepts or ideas (nodes) in the material •represent their interrelationships (links) using a set of named links to code relationships	•outlining technique •organizing/manipulating problem space •facilitate problem-solving	•assists in viewing overall concept •links may aid in retrieval	more constraining than pattern noting
Analysis of Key Ideas	Structural alternative to networking aided by worksheets which specify categories of definition and comparison.	•identify key ideas/concepts •develop systematic definitions and elaborations of the concepts •interrelate important pairs of concepts	•(see networking) •elaborate, compare concepts	helpful for learners requiring structure or who have limited study skills	more structured/ constraining

Structural Knowledge Learning Strategies

Strategy	Description	Procedure	Uses	Advantages	Disadvantages
NAIT (the Node Acquisition and Integration Technique)	A structured semantic networking technique.	•identify important concepts •describe the links between concepts •completion of definition worksheets which require learners to identify six types of relationships for each key concept; characteristics and descriptors, antecedents, consequences, evidence, subsets, supersets •comparison worksheets (compare/contrast concepts)	•production of more complete concept definitions •integration of information	•learners produce more varied and complete definitions •learners integrate new information •aids in identifying what is most important in a passage	•time •training

ASSESSING KNOWLEDGE STRUCTURES

Strategy	Description	Uses	Advantages	Disadvantages	Content
Reading Time Tests	A sentence is broken into propositions by the experimenter. Subject's reading time is measured and correlated with the number of propositions.	Construct Validity of propositions	Easily Administered	Usually limited to laboratory use. Timing devices required.	Propositions
Semantic Recall Tests	Subjects are given paragraph. Later are given sentences and are asked whether or not they have seen the sentence before.	Construct Validity of semantic theories of memory	Easily Administered	Usually limited to laboratory use.	Propositions and semantic theories
Hierarchical Timing Tests	Measured with timing tests using concepts at various levels of generality.	Construct validity of hierarchical memory	Easily Adminstered	Usually limited to laboratory use. Timing Devices are needed.	Hierarchical concept structure
Pattern Notes	Subjects are asked to free associate on paper to a given word. Scored by counting number of links between words.	Assessing complex knowledge structures	Easily Administered and can be interpreted intuitively	Links (relationships) between concepts are not labeled	Structure of schema

ASSESSING KNOWLEDGE STRUCTURES

Strategy	Description	Uses	Advantages	Disadvantages	Content
Free Word Association Tests	Subjects are given a word and are asked to list the first word that comes to mind. Below it, the second word, etc.	Assess cognitive structure and correlate with content structure	Easily Administered	Relationships are not explained	Structure of schema
Controlled Word Association Tests	Subjects are given a list of words and asked to rank order them according to which words are most related in meaning.	Assess cognitive structure and correlate with content structure	Easily Administered. Can be interpreted intuitively	Relationships are not explained	Structure of schema
Tree Construction Tasks	Subjects construct a linear graph in which the intersections are words and the connecting lines are relationships	Assess cognitive structure	Easily Administered	Relationships are not explained	Structure of schema
Concept maps	Subjects are asked to link concepts that relate and label the links. A scoring system exists which can relate map to content structure.	Assess cognitive structure and correlate with content structure	Labeled links make relationships explicit	Scoring system is linked to content structure	Structure of schema

ASSESSING KNOWLEDGE STRUCTURES

Strategy	Description	Uses	Advantages	Disadvantages	Content
Membership Decision Tasks	Subjects are timed as they decide whether an action is involved in performing a given activity.	Assessment of contents of an individual's script. Build script "norms"	Easily administered	All possibilities must be prepared	Scripts or Schema
Generating Examples	Subjects are given a category and asked to generate members or instances of the category.	Judge semantic proximity between class and examples	Easily administered	May interact with general ability to generate examples	Semantic proximity of concepts
Conceptual Models	Concept maps of content structure.	Assess content structure	Easily administered	Disagreement among experts in loosely defined fields	Content Structure
Concept Typicality Ratings	Subjects are given a superordinate category and are asked to rate the typicality of given instances.	Judge semantic proximity between class and examples	Easily administered	Many possibilities must be prepared	Semantic proximity of concepts
Subtraction Technique	Time to complete a task is compared with time to complete a similar task with one element varied. Assumed that difference is caused by different processing.	Assess information processing models	Usable way to assess a covert system	Laboratory measurement is necessary. Relies on inferences as to actual processes involved	Productions and production systems

ASSESSING KNOWLEDGE STRUCTURES

Strategy	Description	Uses	Advantages	Disadvantages	Content
Actual Tasks	Subjects perform tasks that require automatic performance.	Infers the existence of productions that underlie performance	Easily judged visually	Relies on logic of inference	Productions or Executive routine
Think-Aloud Tasks	Subject is asked to speak aloud thoughts as he carries out activity or solves a problem.	Assess problem solving strategies or production systems	Makes covert activities visible	Speaking aloud may interfere with thought process or may inhibit natural processes	Productions, production systems, or problem solving strategies
Diagnostic Tests	Carefully created tests that measure components of a process rather than just the outcome.	Assess missing steps of a production system	Are natural to learner if introduced early in instruction		Productions and production systems
Scanning Time	Subjects are timed as they scan "mental pictures."	Construct validity of pictorial memory		Laboratory timing required	Pictorial memory
Mazes	Lab animals are shown various routes and alternatives paths to accomplish goals.	Assess presence or absence of cognitive maps	Visually scored	Questionable external validity as applied to humans	Cognitive maps, pictorial memory, episodic memory

ASSESSING KNOWLEDGE STRUCTURES

Strategy	Description	Uses	Advantages	Disadvantages	Content
Human Mazes	Subjects are put through a disorienting situation and then asked to point to a specific object or a general direction	Assess spatial abilities and sense of direction	Easily administered		Spatial knowledge sense of direction
Field and Ground Tests	Subjects sit in darkened room in movable chair and are asked to orient themselves with a horizon	To determine field dependence or field independence	Replicable and realistic results. Correlation to simpler tests, such as embedded figures test	Complex testing equipment required	Field dependence Field independence or spatial knowledge
Mental Rotation Tasks	Subject is given two pictures of an object and asked to determine whether or not the object in the first picture can be rotated to look like the second one	Construct validity of spatial or pictorial memory. Measurement of pictorial skills	Points to otherwise hidden ability	May require timing devices	Pictorial or spatial knowledge or skills

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